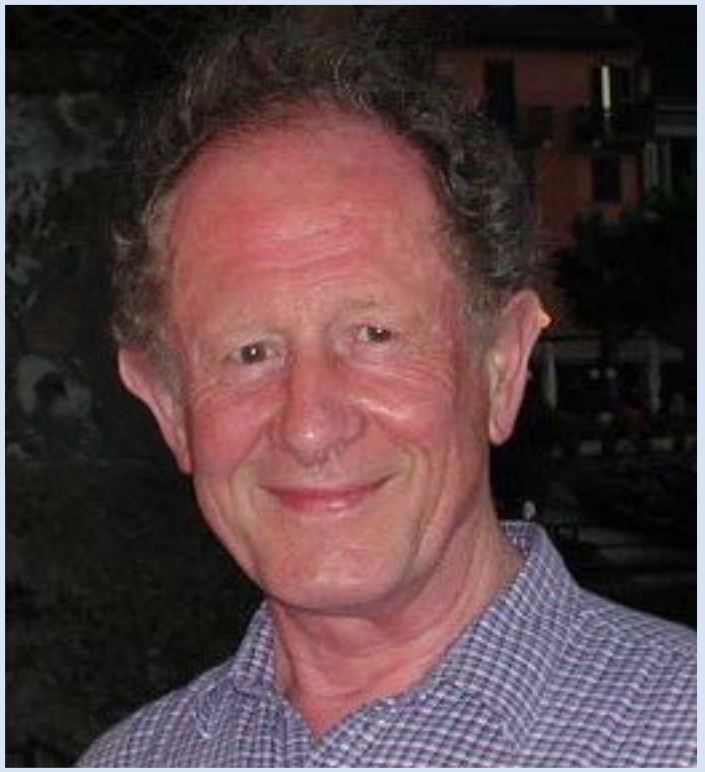
Pressing On, Regardless:

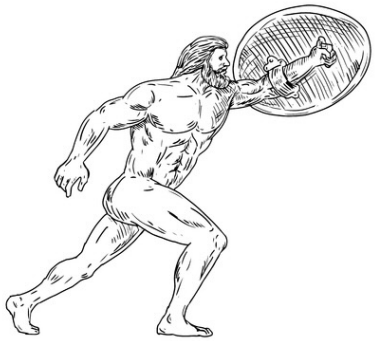
Scientific Impacts of Neil W. Ashcroft



Russell J. Hemley

University of Illinois Chicago
Chicago, IL 60607 USA

23rd APS SCCM Conference
Chicago, Jun 23, 2023

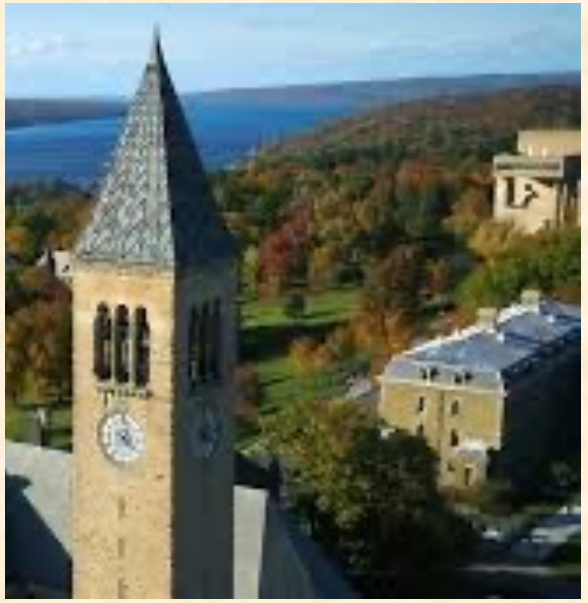


"Press on, regardless"

Theme of the 1986 GRC
N.W. Ashcroft, Chair

Neil William Ashcroft

Nov. 27, 1938	Born, London, England.
1958	BSc, University of New Zealand, Wellington, New Zealand.
1964	PhD, Physics, Cambridge University, Cambridge.
1964 – 1965	Research Associate, University of Chicago.
1965 – 2021	Research Associate to Associate Professor of Physics (1965-1975); Professor of Physics, Laboratory of Atomic and Solid State Physics (LASSP; 1975-1989); Director, LASSP (1979-1984); Horace White Professor of Physics (1990-2006); Horace White Emeritus Professor of Physics (2006-2021), Cornell University.
1978 – 1997	Associate Director (1978-1989); Acting Director (1983 - 1984); and Deputy Director (1990-1997), CHESS, Cornell University.
1984 – 1985	Visiting Fellow, Churchill College, Cambridge University.
1986 – 1987	Chair, Division of Condensed Matter Physics, APS
1987	Member, High T_c Superconductivity Committee, NAS.
1990 – 1992	Chair, Board of Trustees, Gordon Research Conferences
1997	Member, National Academy of Sciences.
1997 – 2000	Director, Cornell Center for Materials Research
Mar 15, 2021	Died, Ithaca, New York.



Cornell University

Scientific Impacts of Neil W. Ashcroft

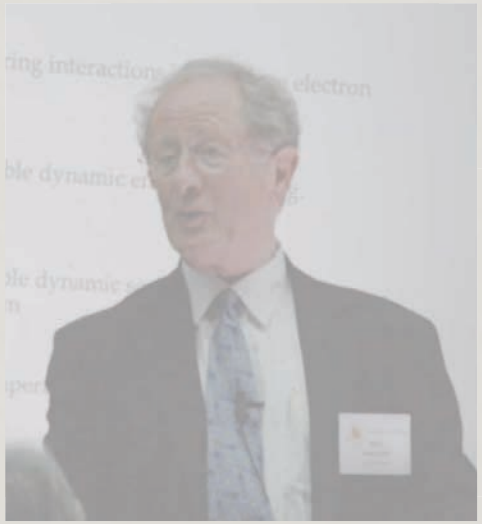
THE SCIENCE

- From Simple Metals to Element One
- Toward a New Periodic Table
- From Atomic Destruction to Electronic Order
- Superconductivity

THE PERSON

- Teacher
- Communicator
- Leader
- Mentor

Scientific Impacts of Neil W. Ashcroft



THE SCIENCE

- From Simple Metals to Element One
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THE PERSON

- Teacher
- Communicator
- Leader
- Mentor

Early Years: *Metals, Simple and Liquid*

Volume 23, number 1 PHYSICS LETTERS 3 October 1966

ELECTRON-ION PSEUDOPOTENTIALS IN METALS*

N. W. ASHCROFT
Laboratory of Atomic and Solid State Physics,
Cornell University, Ithaca, New York

PHYSICAL REVIEW VOLUME 145, NUMBER 1 6 MAY 1966

Structure and Resistivity of Liquid Metals*

N. W. ASHCROFT
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York
AND
J. LEKNER
Department of Physics and the Institute for the Study of Metals, University of Chicago, Chicago, Illinois
(Received 13 December 1965)

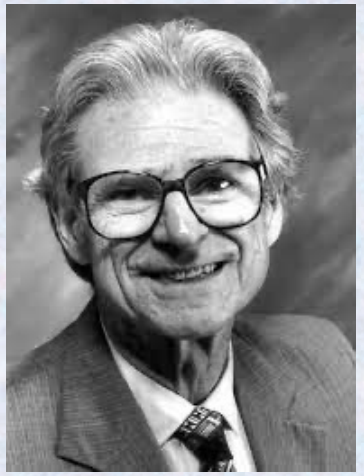
PHYSICAL REVIEW VOLUME 155, NUMBER 3 15 MARCH 1967

Compressibility and Binding Energy of the Simple Metals*

N. W. ASHCROFT AND DAVID C. LANGRETH
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York
(Received 15 August 1966; revised manuscript received 3 October 1966)

"Aluminium... Marvelous stuff, you can even wrap your sandwich in it."

The ‘Simplest’ Metal



Edwin Salpeter

VOLUME 21, NUMBER 26 PHYSICAL REVIEW LETTERS 23 DECEMBER 1968

METALLIC HYDROGEN: A HIGH-TEMPERATURE SUPERCONDUCTOR?

N. W. Ashcroft
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York 14850
(Received 3 May 1968)

Application of the BCS theory to the proposed metallic modification of hydrogen suggests that it will be a high-temperature superconductor. This prediction has interesting astrophysical consequences, as well as implications for the possible development of a superconductor for use at elevated temperatures.

$$T_c = 0.85\Theta_D \exp(-1/N_0 V),$$

Expected high Debye frequency, large DOS at E_F and large electron-phonon coupling

Element One

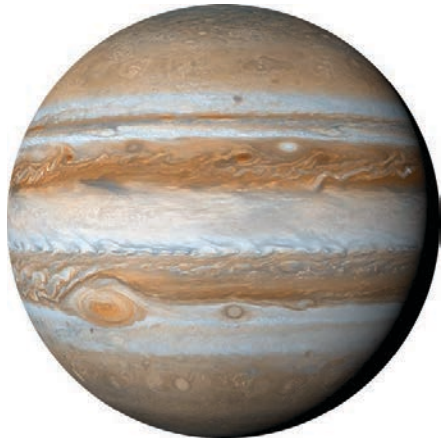
- *Very high temperature superconductor*

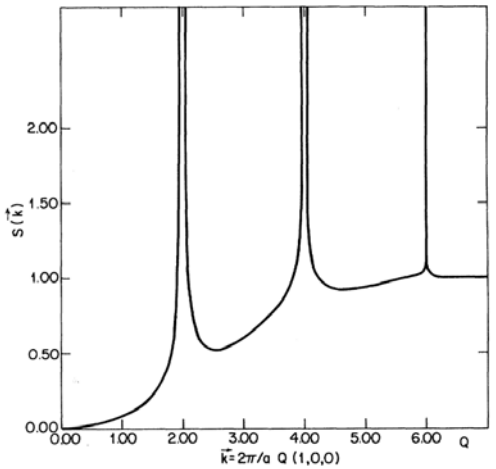
N.W. Ashcroft, *Phys. Rev. Lett.* (1968)

$$T_c = 0.85\Theta_D \exp(-1/N_0 V),$$

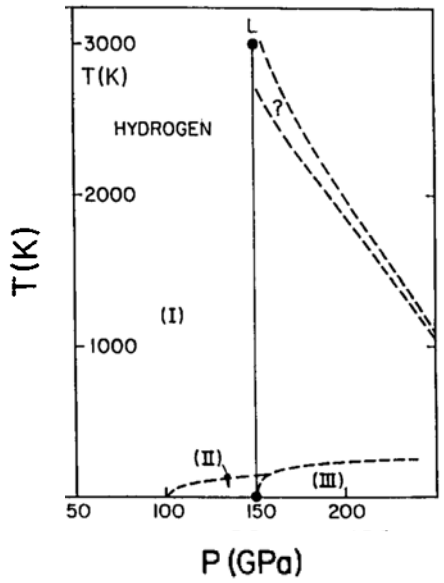
- *Liquid metallic hydrogen*

K.S. Mon et al., *Phys. Rev. B* (1980);
J. Oliva & N.W. Ashcroft, *Phys. Rev. B* (1981)





The Hydrogen "pbA's"
(predicted by Ashcroft)



- *Possible ground state liquid*

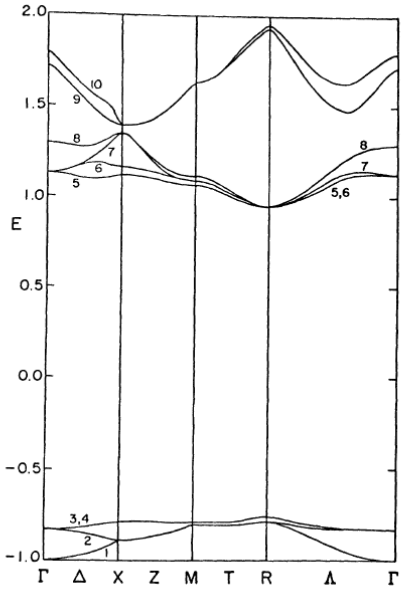
J. Hammerburg & N.W. Ashcroft, *Phys. Rev. B* (1974); D.M. Straus & N.W. Ashcroft, *Phys. Rev. Lett.* (1977); N.W. Ashcroft, *JPCM* (2000)

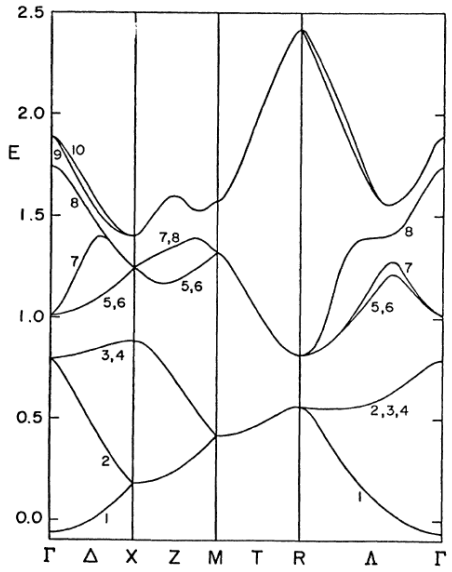
T. Kaxiras, *Bull. Am. Phys. Soc.* (1994)

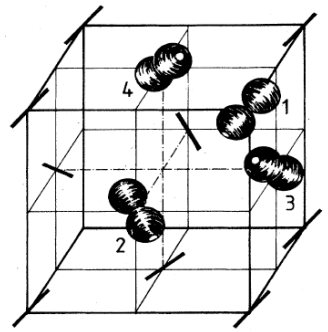
Element One

- *Band overlap metallization*

C. Freidli & N.W. Ashcroft, *Phys. Rev. B* (1977)



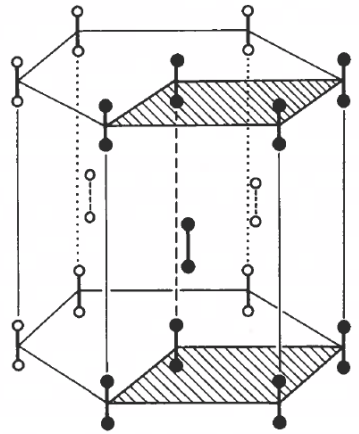


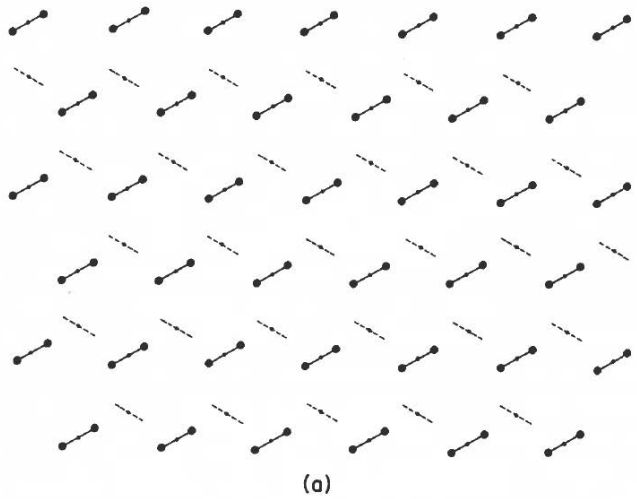


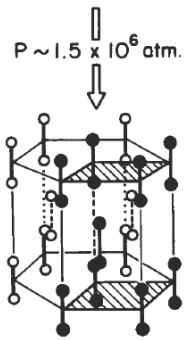
The Hydrogen pbA's

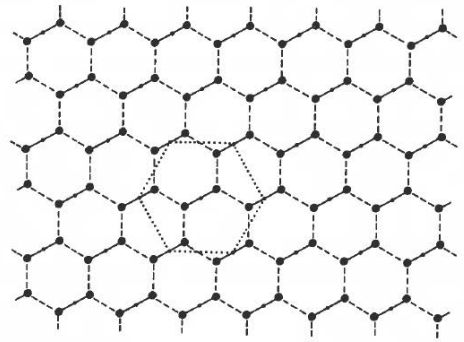
- *'Delayed' onset of metallization in the solid*

N.W. Ashcroft, in *Molecular Systems Under High Pressure* (1991)









Element One

"Reluctant alkali or a tenacious halogen?"

N.W. Ashcroft, *Physics World* (1995)

➢ *Lowering solid metallization pressure*

VOLUME 50, NUMBER 17 PHYSICAL REVIEW LETTERS 25 APRIL 1983

Approaches for Reducing the Insulator-Metal Transition Pressure in Hydrogen

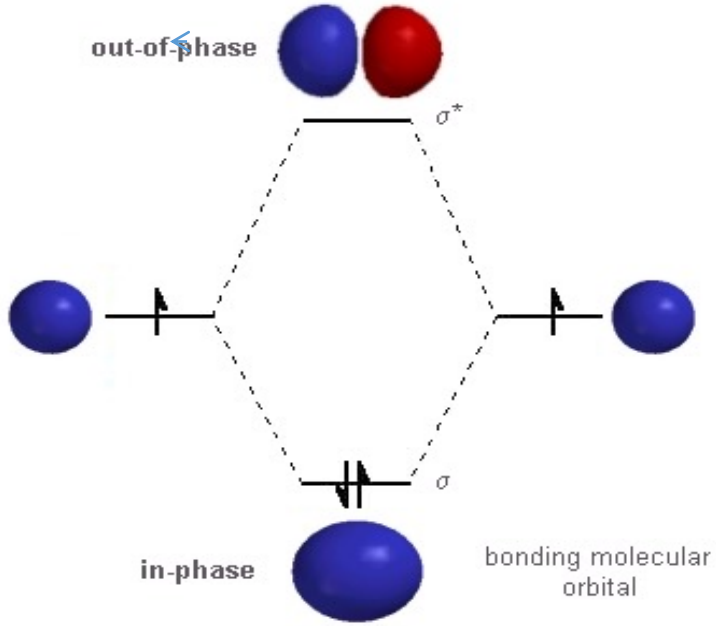
A. E. Carlsson and N. W. Ashcroft
Laboratory of Atomic and Solid State Physics and the Materials Science Center, Cornell University, Ithaca, New York 14853

➢ *Very high T_c hydrogen-dominant alloys*

VOLUME 92, NUMBER 18 PHYSICAL REVIEW LETTERS week ending 7 MAY 2004

Hydrogen Dominant Metallic Alloys: High Temperature Superconductors?

N.W. Ashcroft
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York 14853-2501, USA
Donostia International Physics Center, San Sebastian, Spain
(Received 29 December 2003; published 6 May 2004)



The Hydrogen pbA's

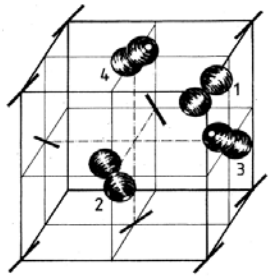
➢ *Mechanism of fluid metallization*

W.B. Nellis et al., *Phil. Trans. Royal Soc.* (1996)

Element One

- *Superconducting molecular metal*

C.F. Richardson & N.W. Ashcroft, *Phys. Rev. Lett.* (1997)



- *Superconducting superfluid*

PRL 95, 105301 (2005) PHYSICAL REVIEW LETTERS week ending 2 SEPTEMBER 2005

Observability of a Projected New State of Matter: A Metallic Superfluid

E. Babaev
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York 14853-2501, USA
Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway

A. Sudbø
Department of Physics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway

N. W. Ashcroft
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York 14853-2501, USA
(Received 13 June 2005; published 1 September 2005)

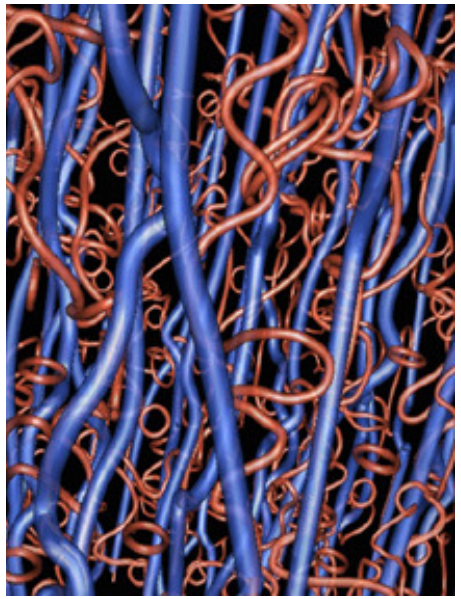
- *Novel superconducting mechanisms*

liquid; coupled e-e and *p-p* pairing

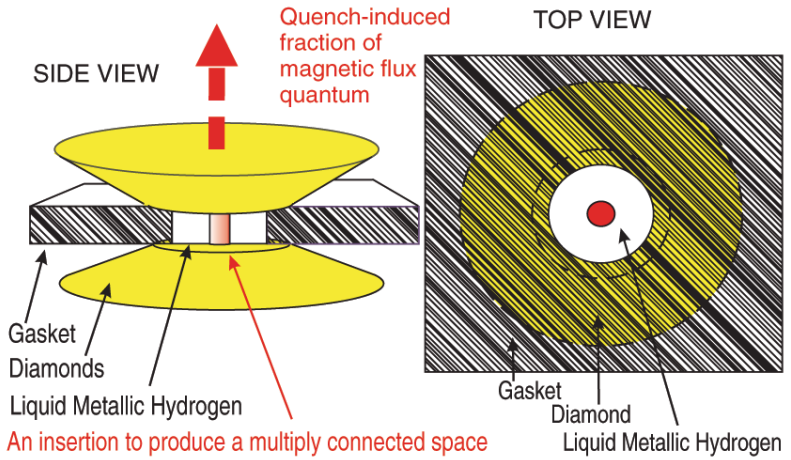
$$\rho_p^{(2)}(\boldsymbol{r},\boldsymbol{r}') = \langle \hat{\rho}_p^{(2)}(\boldsymbol{r},\boldsymbol{r}') \rangle = \rho_p^{(1)}(\boldsymbol{r})\rho_p^{(1)}(\boldsymbol{r}')g_p(\boldsymbol{r},\boldsymbol{r}')$$

J.E. Jaffee & N.W. Ashcroft, *Phys. Rev. B* (1981); K. Moulopoulos & N.W. Ashcroft, *Phys. Rev. B* (1990); *ibid. (*1999)

The Hydrogen pbA's



>400 GPa



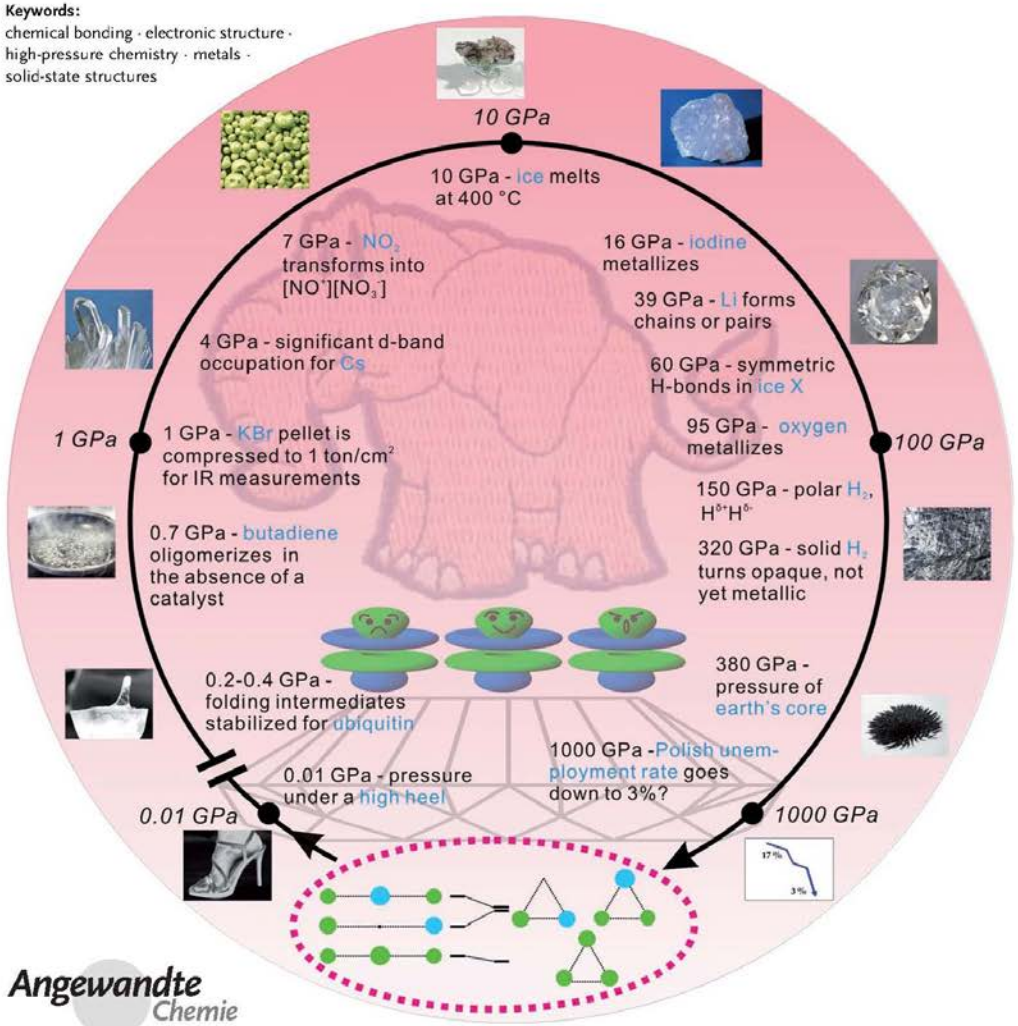
I. Babaev et al., *Nature (*2004); *Phys. Rev. Lett.* (2005)

New Perspectives on the Periodic Table

The Chemical Imagination at Work in *Very* Tight Places

Wojciech Grochala, Roald Hoffmann,* Ji Feng,* and Neil W. Ashcroft**

Keywords:
chemical bonding · electronic structure · high-pressure chemistry · metals · solid-state structures



Roald Hoffmann

What made our collaboration work was his sincere appreciation of chemistry, of the approximate, fuzzy ways of understanding we have of complex patterns. No resort to the reductionist way of thinking of some physicists. That made us a good scientific couple. His enthusiasm for chemistry showed up in his continued love for the Periodic Table, which he understood was as much a tool for allowing difference and tuning as it was for spotting similarity.

47 publications

EFree U.S. DEPARTMENT OF ENERGY | Office of Science
Energy Frontier Research Center

Toward a New Periodic Table

- *Electronic order from the breakdown of atoms*

INSTITUTE OF PHYSICS PUBLISHING — JOURNAL OF PHYSICS: CONDENSED MATTER

J. Phys.: Condens. Matter **16** (2004) S945–S952 — PII: S0953-8984(04)74858-4

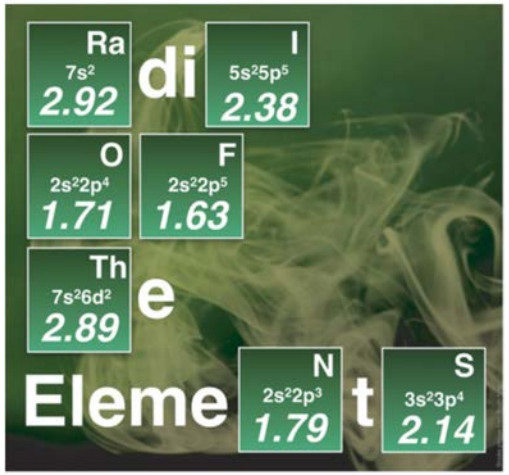
Bridgman's high-pressure atomic destructibility and its growing legacy of ordered states

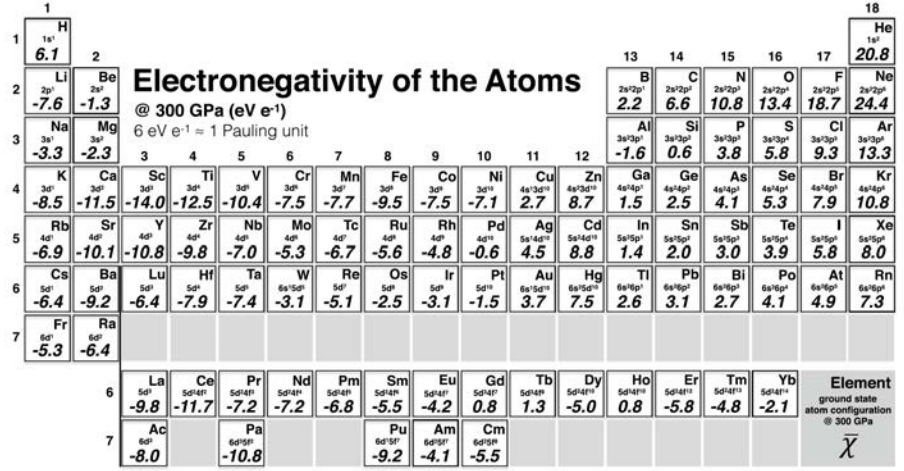
N W Ashcroft

Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, NY 14853-2501, USA

Bridgman Award Lecture (2003)

- *Size and electronegativity of squeezed atoms*





M. Rahm et al., *Chem.* (2016); *JACS* (2019)

- *White dwarfs as quantum crystals*

Fate of astrophysical carbon

G. Chabrier et al., *Nature* (1992)

Viewpoint *Physics* **2**, 65 (2009)

Pressing some boundaries in Mendeleev's chart

N. W. Ashcroft
Department of Physics, Cornell University, Ithaca, NY 14853-2501, USA

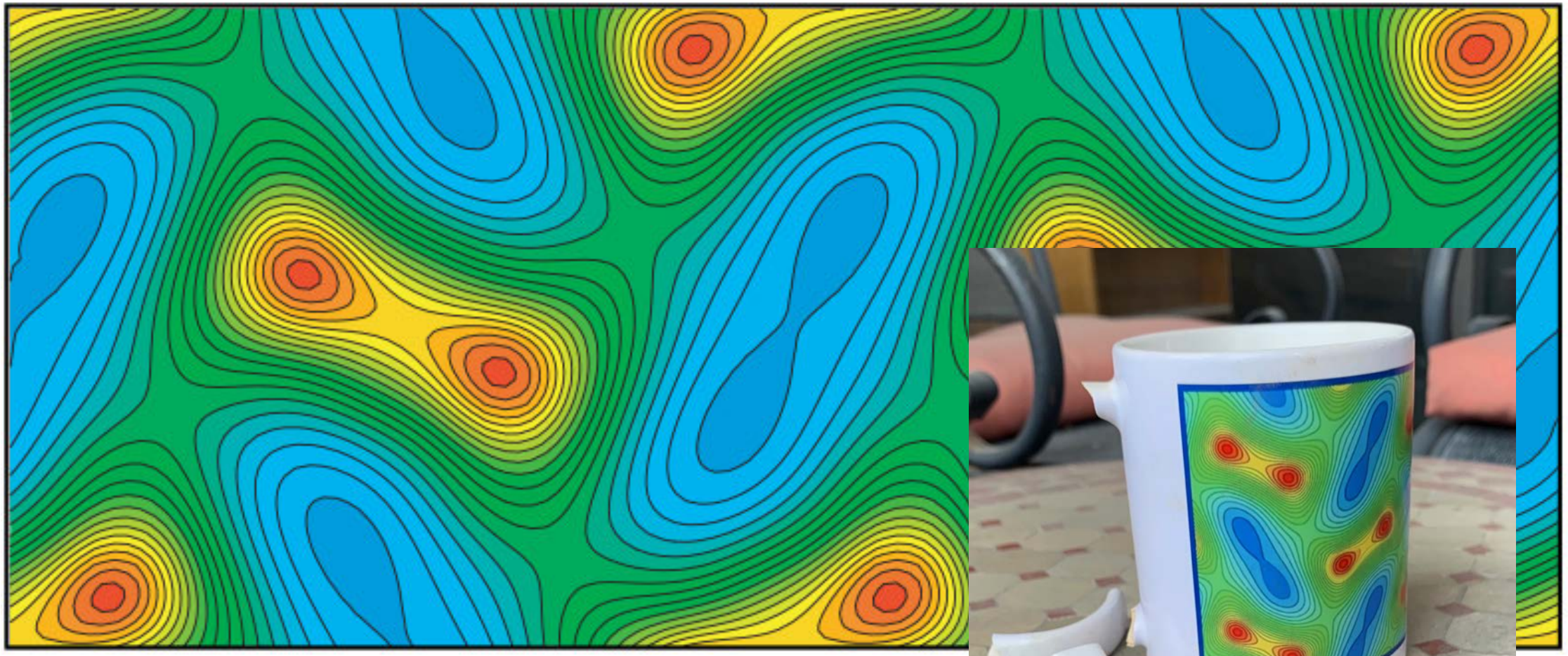
Published August 3, 2009

And emergent phenomena along the way

Toward a New Periodic Table

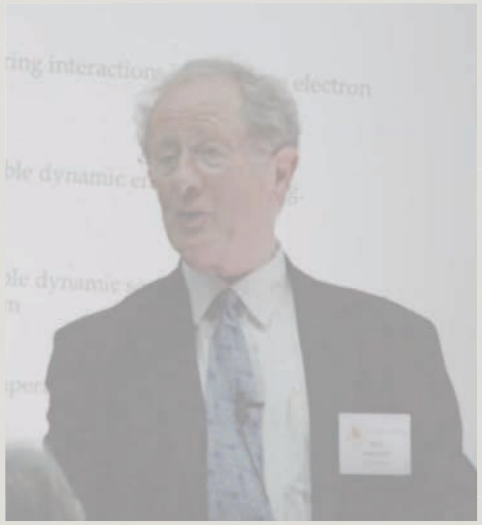
J.B. Neaton & N.W. Ashcroft, *Nature* (1999); *Phys. Rev. B* (2001)

- *Symmetry breaking and high-pressure electrides*



Interstitial Electron Localization: Lithium *Cmca-4*
Now predicted and found in numerous elements

Scientific Impacts of Neil W. Ashcroft



THE SCIENCE

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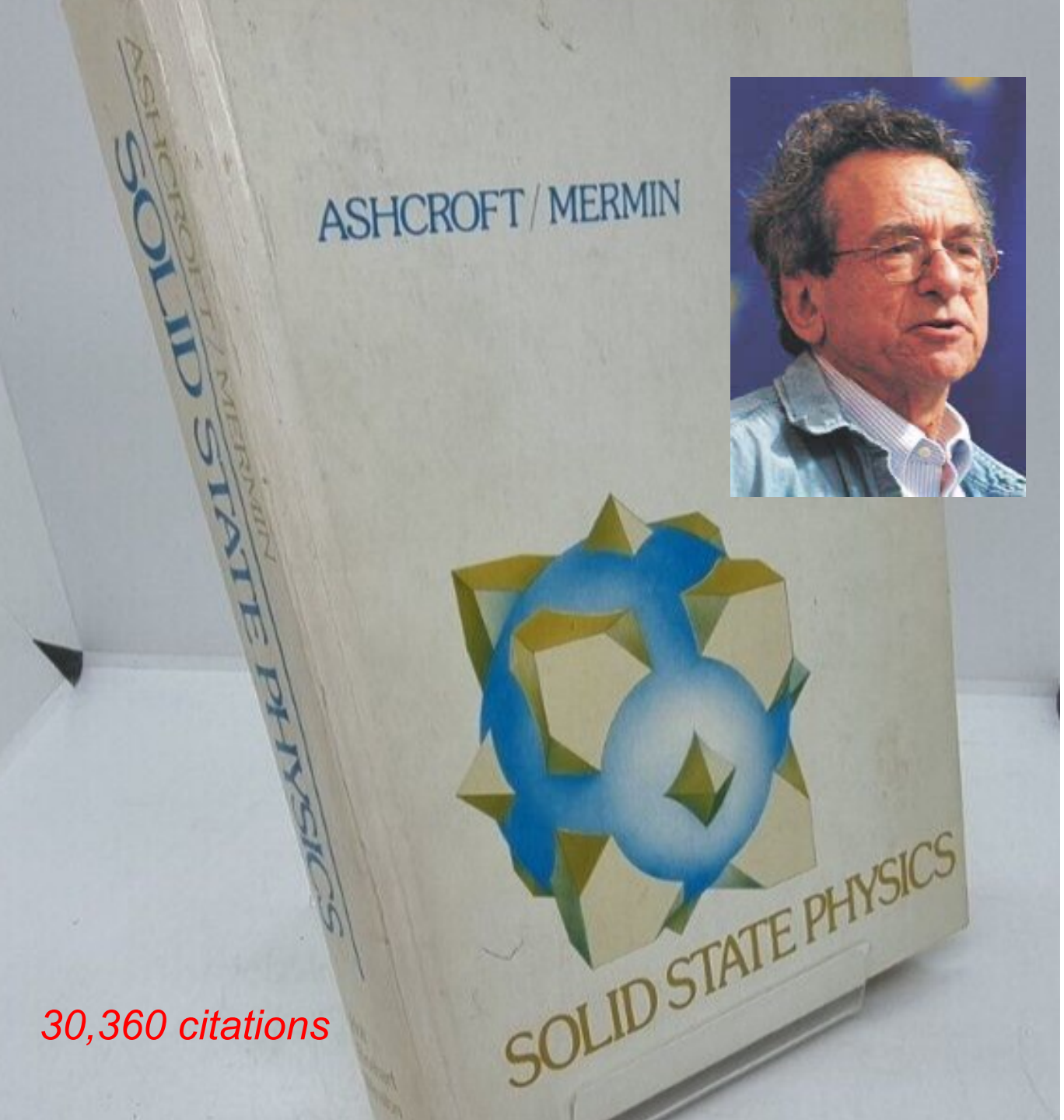
- Toward a New Periodic Table
- From Atomic Destruction to Electronic Order
- Superconductivity

THE PERSON

- Teacher
- Communicator
- Leader
- Mentor



30,360 citations

”Check it out in Ashcroft and Mermin”

Neil W. Ashcroft
1938–2021

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
N. David Mermin

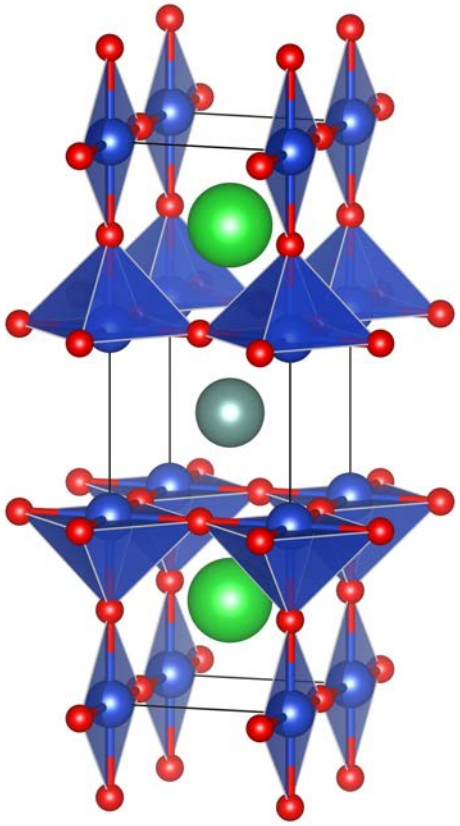
NATIONAL ACADEMY OF SCIENCES

Inspiring High T_c Superconductivity

https://youtu.be/JcprXckcGrc

Chair of the APS DCMP and
'Woodstock of Physics' (1987)

Discovery of High T_c Cuprates




The New York Times

WHITE HOUSE KNEW OF A SHIFT ON IRAN, C.I.A. OFFICIALS SAY

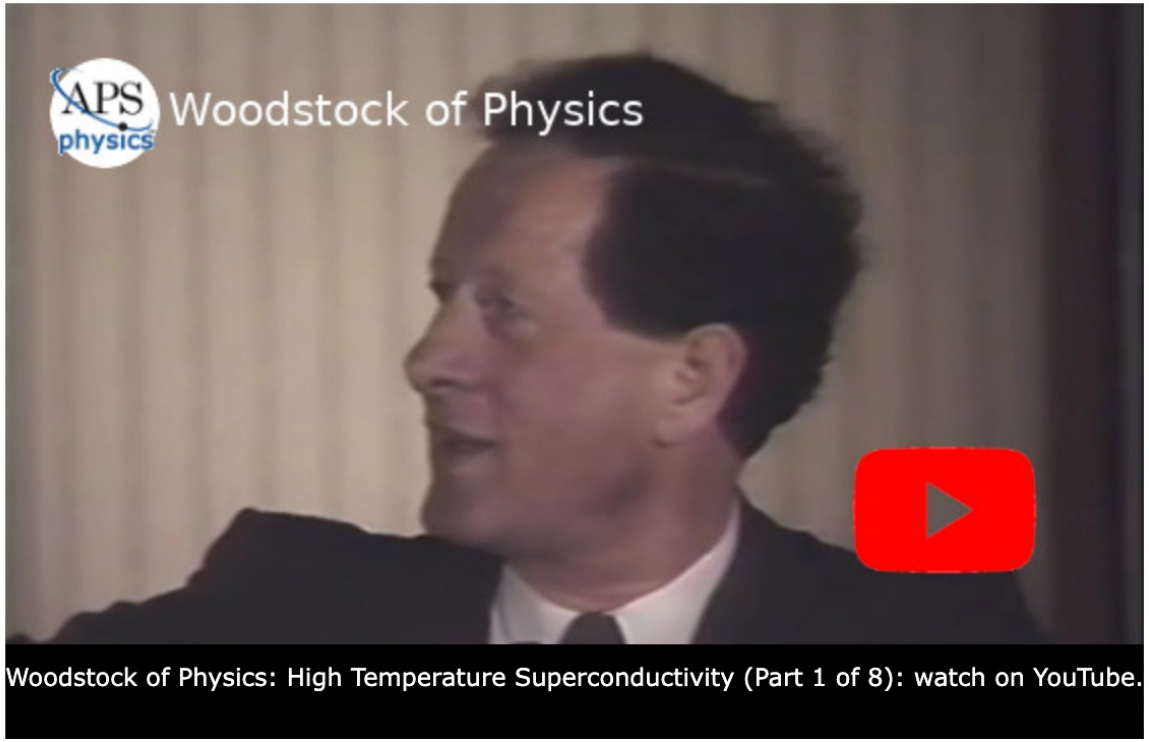
REAGAN RENOUNCES HIS IRAN INITIATIVE; BARS A RECURRENCE

Serious Crimes in New York City Rise 5%, First Increase in 5 Years

Facing the Nation Again

Meese Says U.S. Will Support Drug Tests for New Teachers

Discoveries Bring a 'Woodstock' for Physics



"What we're see/ing here is one of the most exciting developments in decades," he said. "It's utterly remarkable, and I think there's more to come."
New York Times (Mar. 20, 1987)

Still Higher T_c Superconductors

TOWARDS ROOM TEMPERATURE SUPERCONDUCTIVITY: WORDS OF ENCOURAGEMENT

2000
GRC

" ...room temperature superconductivity (regardless of a thousand statements by theorists and an equal number of theories) is in my opinion – pure science fiction.

...

I can think of no other field in modern physics in which so much has been predicted without producing a single experimental success."

B.T. Matthias, Physics Today **24**, (#8), 21 (1971)

",.. Ginzburg [g], Schneider [s] and Ashcroft [a] have predicted superconductivity in metallic hydrogen at astronomic pressures, at astronomic temperatures, found only at astronomic distances"

B.T. Matthias, Comments on Solid State Physics, **3**, 93 (1970)

Observations:

- T_c seems to have been rising of late with the number of elements present in metallic compounds (the dark hand of complexity?)
- There are 90+ elements
- "... [Volte face?]... The field of ternary superconductors is still comparatively new and there is still some hope."
  B.T. Matthias, September 1980, in "Ternary Superconductors" (Ed, Fradin)
  - Acknowledging complexity in the electronic domain?

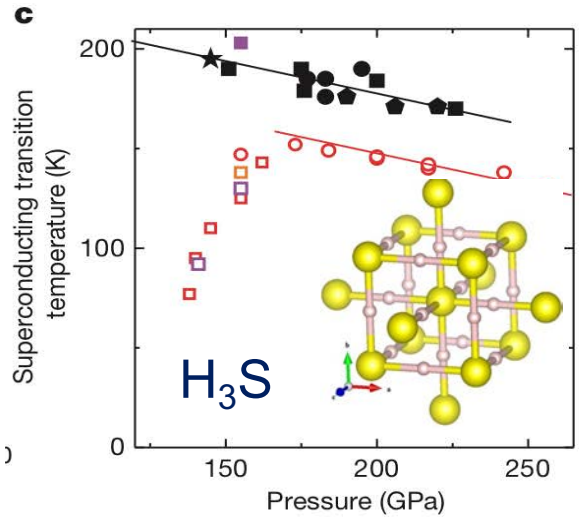
---

[g] V.L. Ginzburg, Contemp. Phys. **9**, 355 (1968)
[s] T. Schneider, Helv. Phys. Acta **42**, 957 (1969)
[a] N.W. Ashcroft, Phys. Rev. Letts. **21**, 1748 (1968)

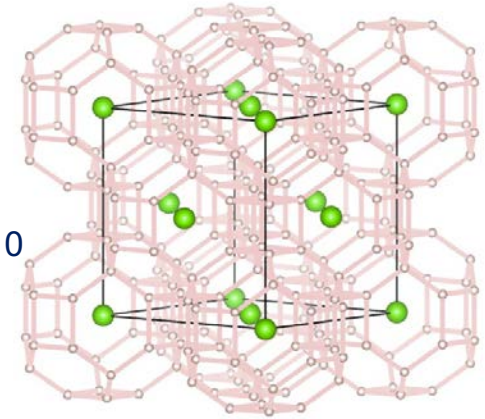
Realizing Still Higher T_c Superconductors

- *Very high T_c hydrogen-dominant alloys*

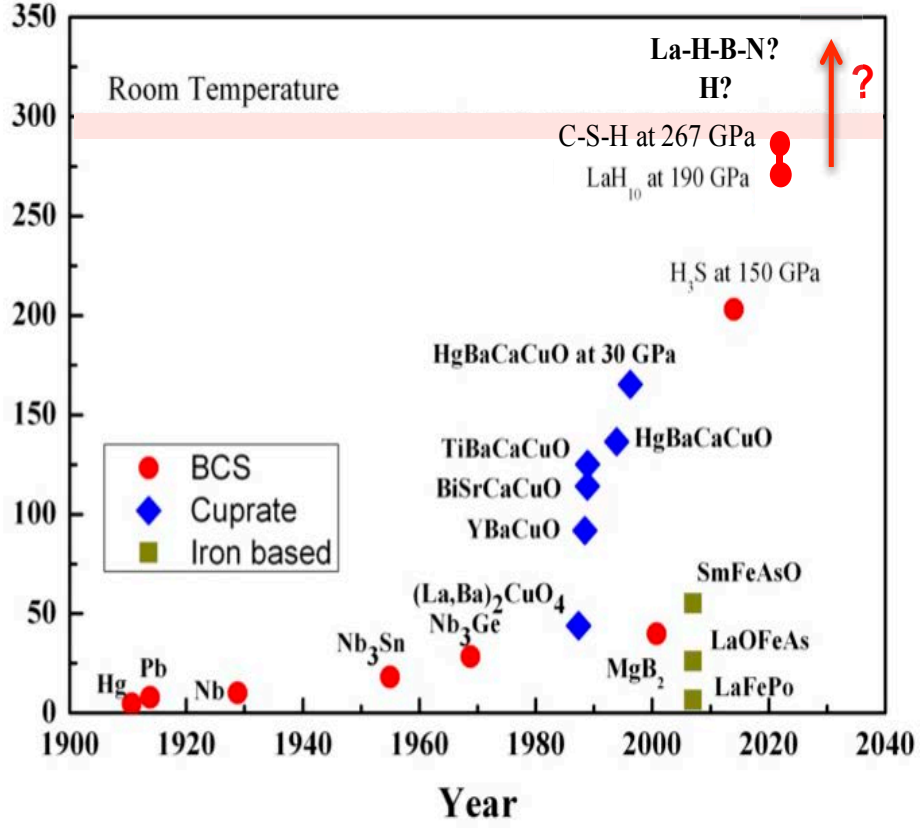
N.W. Ashcroft, *Phys. Rev. Lett.* (2004)



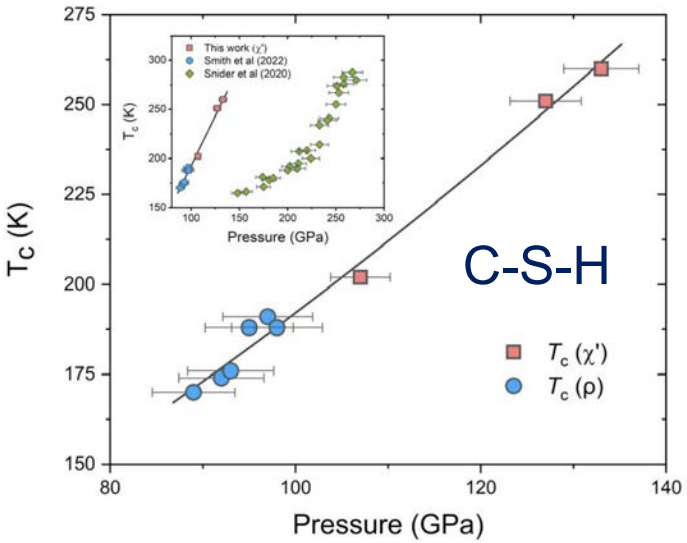
A.P. Drozdov et al., *Nature* (2015)



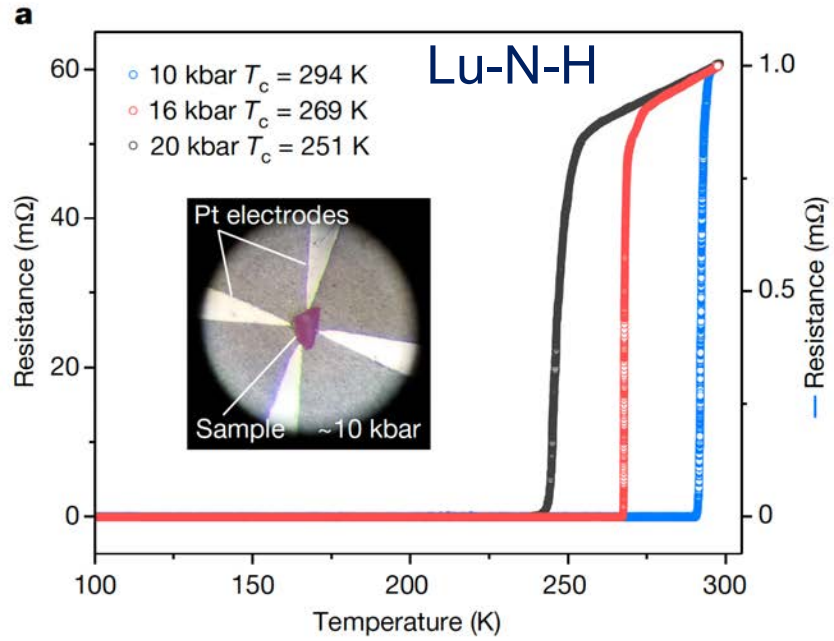
H. Liu *et al.*, *PNAS* (2017)



L. Boeri et al., *JPCM* (2022)



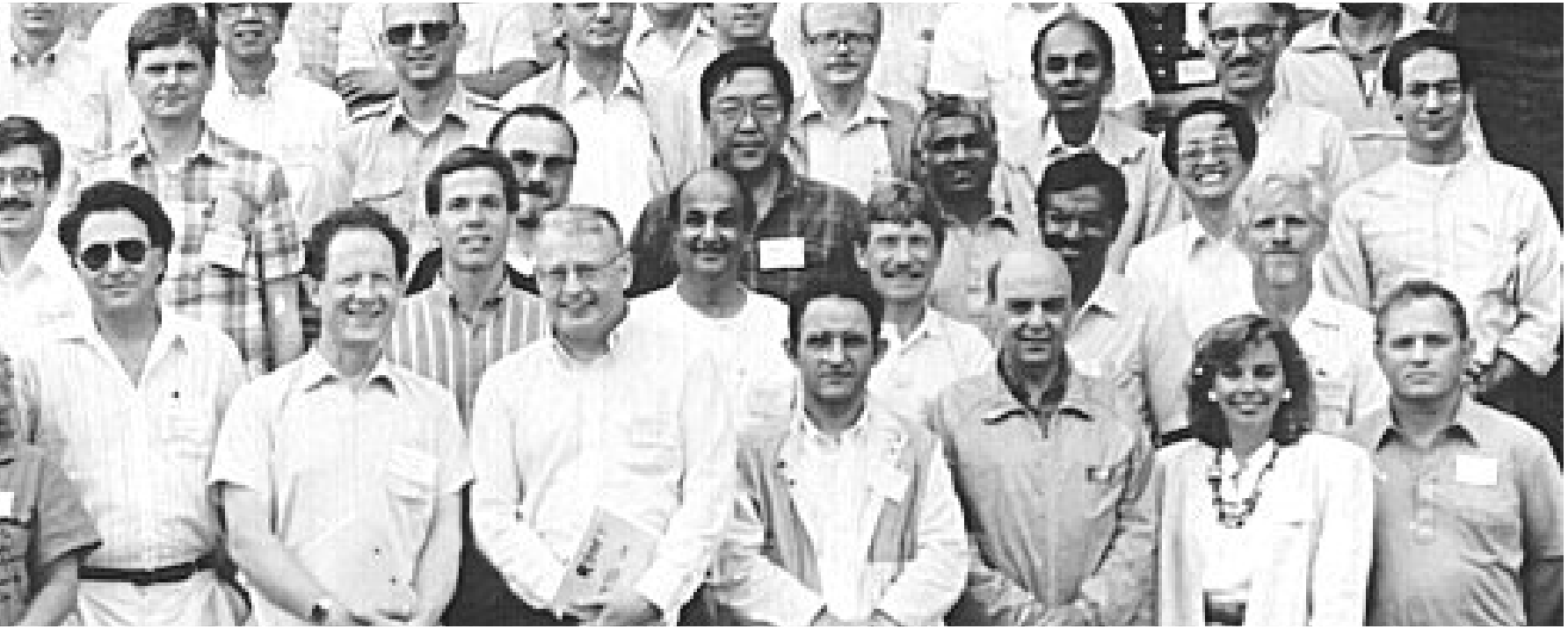
H. Pasan *et al.*, *arXiv* (2023)

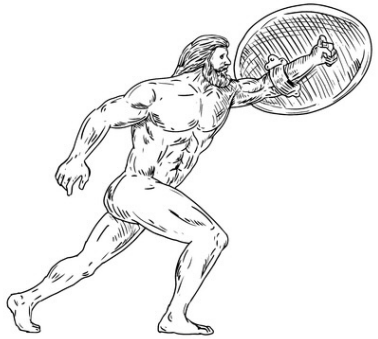


N. Dasenbrock-Gammon *et al.*, *Nature* (2023)

Dedication to the Community

Dedication to the Community



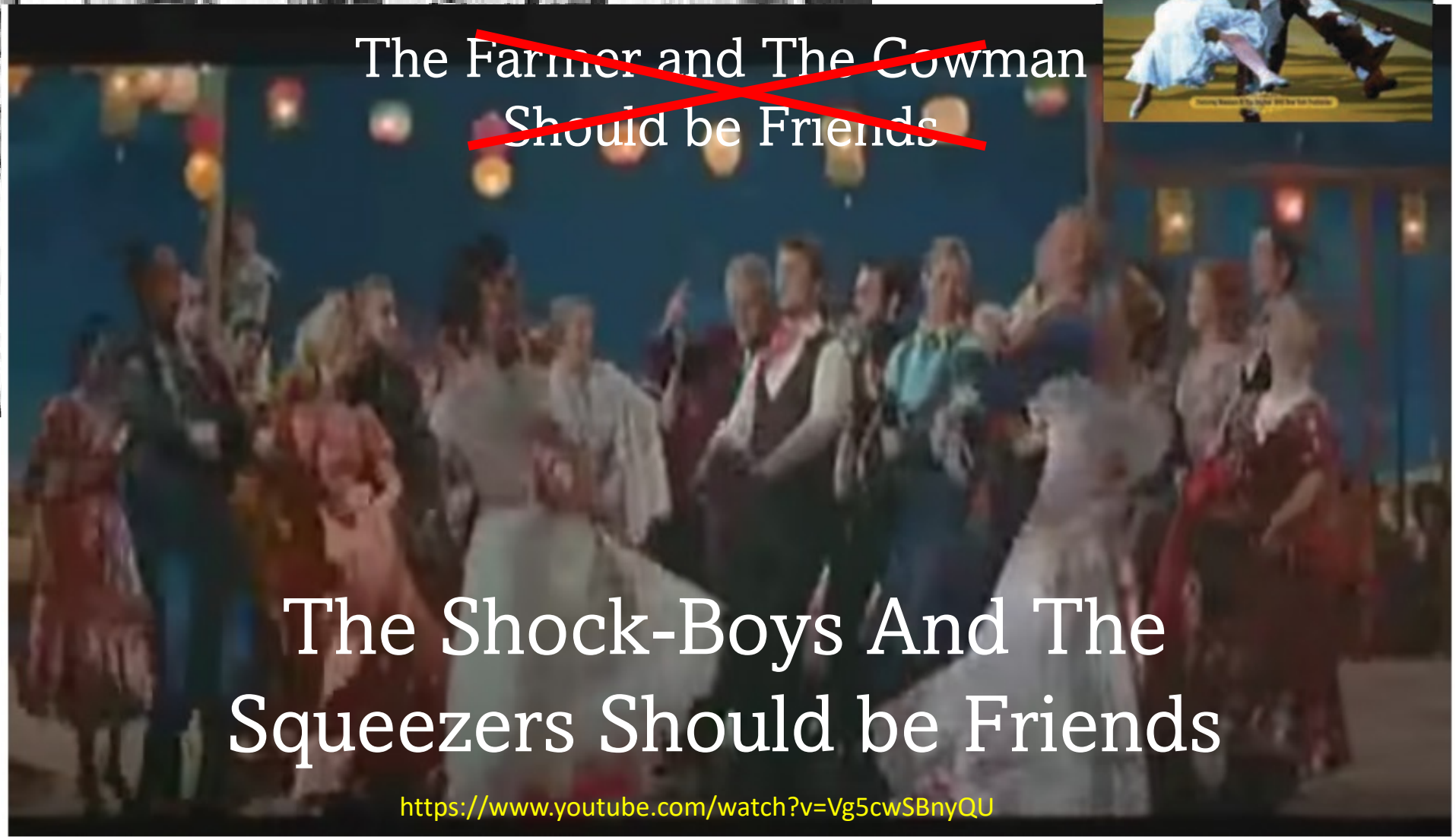


"Press on, regardless"

Theme of the 1986 GRC
N.W. Ashcroft, Chair

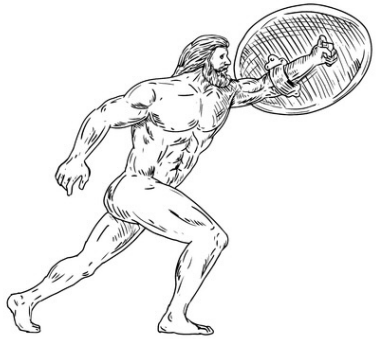
Dedication to the Community

~~The Farmer and The Cowman Should be Friends~~



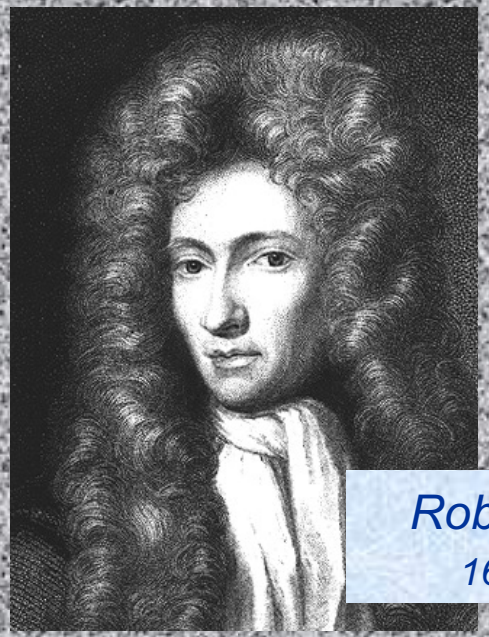
The Shock-Boys And The Squeezers Should be Friends

https://www.youtube.com/watch?v=Vg5cwSBnyQU



"Press on, regardless"

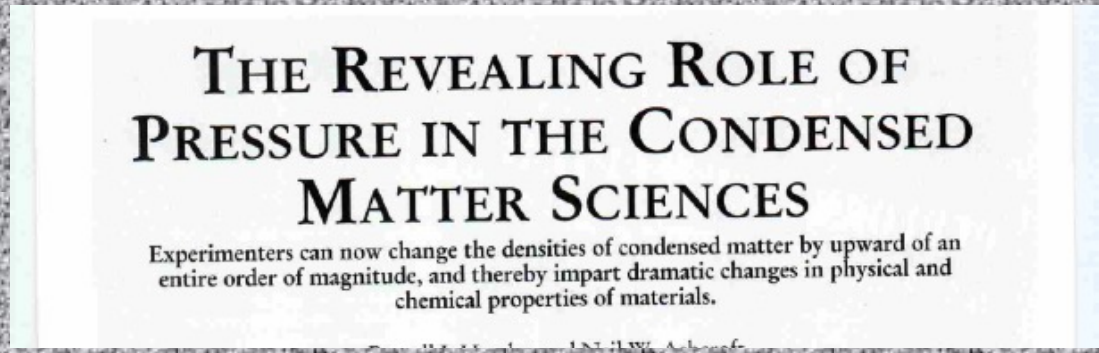
Theme of the 1986 GRC
N.W. Ashcroft, Chair



Robert Boyle
1627-1691

". . . perhaps the pressure of the air might have an interest in more phaenomena than men have hitherto thought."

"Touching the Spring of the Air"
New Experiments in Physics and Mechanics (1660)

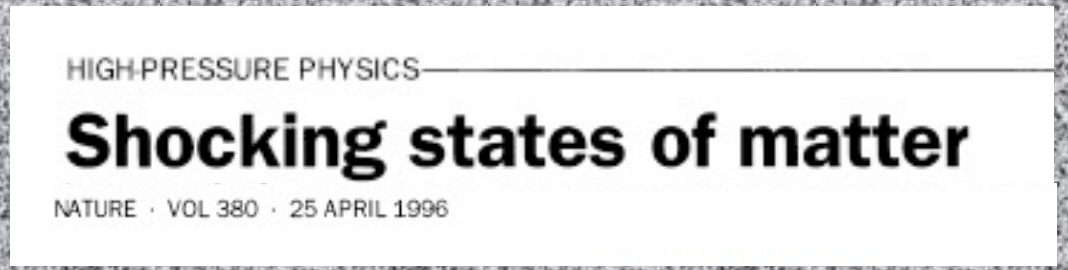

THE REVEALING ROLE OF PRESSURE IN THE CONDENSED MATTER SCIENCES

Experimenters can now change the densities of condensed matter by upward of an entire order of magnitude, and thereby impart dramatic changes in physical and chemical properties of materials.

Neil W. Ashcroft
1938-2021

". . . More than three centuries later, we can see how right he was, as the systematic use of pressure has led to considerable insight into the properties of matter, especially its electronic properties."

Physics Today ***51****, 26-32 (1998)*


HIGH-PRESSURE PHYSICS

Shocking states of matter

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- APS for sponsoring the Award
- Congratulations: Rick Kraus
- *Thank you for this opportunity and for your attention*